ANTIQUARIAN HOROLOGY

AND THE PROCEEDINGS OF THE ANTIQUARIAN HOROLOGICAL SOCIETY

Fig. 1b. p.28.

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ANTIQUARIAN HOROLOGY

and the proceedings of the ANTIQUARIAN HOROLOGICAL SOCIETY

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CONTENTS

OLD FRIENDS

FOR all of us old friends are an important part of our lives. They sustain us in times of stress, make us feel wanted when we feel rejected by the rest of the world and help us to climb out of the pit when we lost heart in what we are doing. Our clocks are some of the most dependable of old friends, always speaking with the same voice and quietly soothing us whatever the time of day or night.

ROBERT FOULKES

After we had started the printing of this issue I learnt of the sudden death of Robert Foulkes. A founder member of the society he always played an important part in its activities. As editor I received from him warm appreciation of what I tried to accomplish and hearty encouragement. Hazel and I will always remember our encounters in auction rooms which always began with his saying "very busy - can't stop - it's my business you know" and followed with a warm and friendly conversation of considerable length. We will miss him. A full obituary will appear in the June issue.

EFFECTS OF THE GRAVITATIONAL ATTRACTIONS OF THE SUN AND MOON ON THE PERIOD OF A PENDULUM

by Pierre H. Boucheron

ABSTRACT

THE purposes of this paper are threefold: first to provide the serious pendulum horologist with some practical information on the subject, second to epitomize a fairly extensive literature search in the field of geophysics and finally to report on some recent work with a Shortt master pendulum. A useful bibliography is included.

INTRODUCTION

Immediately one starts to read a paper or book on the subject of: gravity, tides or Earth's rotation one is confronted with a whole new vocabulary of terms and notation. So before proceeding into the main body of this discussion, it would be best to spend a little time defining some of the more commonly encountered terminology:

diurnal — having a period of one day.

Doodson's constant — $G = 26.206\ cm^2/sec^2$. Relates the effect of the Moon's gravitational attraction to the force of gravity on the Earth's surface as follows: $G = (3/4)mga_1^2,\ a^2/c^3$ where: $m = 1/81.53$ = Moon's mass/Earth's mass, $g = 982.04\ cm/sec^2$ = mean gravity, $a_1 = 6371.2$ km = Earth's mean radius, a = distance of observer to Earth's centre (nominally $a = a_1$), $c = 60.27a_1$ = half major axis of lunar orbit. $G^1 = 0.46051G$ = effect of Sun's gravitational attraction (about ½ lunar).

ephemeris — a tabular statement of the assigned places of a celestial body for regular intervals.

evection — perturbation of the Moon's orbit due to the attraction of the Sun.

gal — 1 cm/sec^2. The standard unit of acceleration used in gravimetry; named in honour of Galileo. Thus Earth's standard gravity g = 982.04 gals. 1 microgal = 1E-06 gal.

nutation — wobble of the Earth's axis. Common usage includes variation of Earth's rotation rate and all other factors (some 230 terms) affecting celestial orientation.

Love's numbers h & k. The anelastic Earth's crust deforms in a rather complex manner in response to the gravitational attractions of the Moon and Sun. h is the ratio of the height of the Earth's tide to the static ocean tide. k is the added gravity produced by the deformation of h.

sidereal time — the sidereal day is the interval between two successive transits of a point on the celestial sphere over the upper meridian of a place; 23 hours, 56 minutes, 4.09 seconds of mean solar time. Because the Earth makes one trip around the Sun in completing its orbit it effectively adds approximately one rotation. This means that the time for one complete rotation, measured in solar time, must be reduced by one part in 365. 1 mean solar second = 1.00273 79093 57095 sidereal second.

A word of caution. When scrutinizing the performance of high precision pendulum clocks reported prior to say 1945-50, remember that we did not have accurate values for changes in Earth's rate of rotation. These can sum up to as much as one second in six months. Furthermore a pendulum will respond to changes in local gravity. If these changes persist, say on an annual or semi-annual period, then the clock will sum the error of its rate. Do we blame the clock for accurately reporting what it sees?

EARLY WORK

Perhaps the first person to predict the effects of the gravitational attractions of the Sun and Moon on the period of a pendulum was Sir Harold Jeffrey's in 1928 (Ref. 1). Using figures from George Darwin's tables and early estimates of Love numbers, Jeffreys predicted the amplitude of the error in timekeeping due to the semi-diurnal lunar tide M_2 to be 4.5E-04 second at the equator. To be useful this value must be put into an equation containing arguments for the latitude of the observer (λ) and the phase of the lunar tide 2ø having a period of approximately 12 hours 25 minutes, specifically:

$$(\Delta t/t) = 2.25E\text{-}04\cos^2(\lambda)\cos(2\phi) \text{ seconds/hour.} \quad (2)$$

Jeffreys lists other tides, notably: K_1, O and S_2 which should be taken into account. They are easily calculated as simple percentages of M_2. Considering the lack of good data, his estimates were surprisingly close to subsequent experimental findings.

In 1928 Mr. Alfred Loomis of Tuxedo Park, New York invented a form of oscillograph which he called a chronograph (Ref. 2). It was capable of recording the timing impulse of a Shortt clock with a resolution of one millisecond and it was synchronized by a newly developed highly stable quartz crystal oscillator operated at the Bell Telephone Laboratories in New York City. Loomis then proceeded to record more than a year's data on the performance of three Shortt clocks. The three clocks were mounted on three separate piers arranged in an equilateral triangle such that the planes of swing of the pendulums were at angles of 60° with respect to each other. No mention is made of the location or orientation of the slaves. A very definite interaction between the pendulums due to coupling via support reaction was discovered. In this particular case the interaction was sinusoidal with a period of 10.5 days and an amplitude of ±0.0015 sec/day producing a maximum accumulated error of 0.05 sec/week.

The data from the Loomis chronograph then analysed by E. W. Brown and D. Brouwer (Ref 3). They calculated the direct attraction of the Moon on the pendulum in the following manner:

$$(\Delta g/g) = (2M/E)\sin^3\pi((3/2)\cos^2 z - \tfrac{1}{2}) \quad (2)$$

where: M = mass of the Moon, E = mass of the Earth, π = paralax of the Moon and z = Moon's zenith distance as a function of time. Using numbers developed by Darwin: semidiurnal tide coefficient = 0.454, E/M = 81.5 and $\sin^3\pi$ = 1/219000, they then wrote:

$$(\Delta g/g) = 2(0.454/1.19E07)\cos^2(\lambda)\cos(2\phi) \quad (3)$$

where 2ø is the argument of the tide with a period of 12 h 25 m and λ = 41°, the latitude of the observation. Substituting:

$$(\Delta g/g) = -4.3E\text{-}08\cos(2\phi) \quad (4)$$

For P = 1 sec (the half period of the pendulum) ΔP due to Δg is:

$$-\int\Delta P dt = \tfrac{1}{2}\int(\Delta g/g)dt = -2.15E\text{-}08(44714^* \text{ sec}/2\pi)\sin(2\phi)$$
$$= -0.000153\sin(2\phi) \text{ in seconds} \quad (5)$$

*There are 44714 seconds in the lunar cycle, approx. 12h 25m and here 2π = 6.2832.

where ø = O when the Moon is on the meridian. They continue by noting [with no calculations shown] that the effect of Earth's anelastic deformation (expressed by Love numbers) will almost double the rate change; however the near presence of ocean tides will deminish the effect by 1/7th and there are other Earth tides to be considered.

The Loomis data were reduced and presented in three ways. Each of the three clocks produces two data points per minute for a total of 8640 readings per day, a prodigious amount of data to handle without a computer. For the first 55 days every single data point was read and averaged into hourly means denoted as M55. Next the data was re-read for 147 days but only at hourly intervals; these data are denoted H55 and H147. In order to clearly show diurnal rate changes the data was subjected to a numerical summing process which today might be called digital filtering. Briefly explained the hourly rates for hour O of each day in a set are added and the total divided by the number of readings in the set. The same procedure is followed with the data for hours 1, 2, 3 . . . . . 23 and the results plotted. The process was applied to the meticulously averaged data M55 and repeated for data H55 and H147. The results are shown in Fig. 1 below.

The procedure to develop the semi-diurnal lunar effects is a bit more complicated. First it is necessary to determine the hour of moonrise for each day during the observation period. Then the hourly data is skewed such that moonrise always occurs during hour O of each day (see Fig. 1A) then the summing process is carried out as before. The result is that most "daily" records will be 25 hours long. The results for the three data sets are shown in Fig. 2.

The data shown in Figs. 1 and 2 are the rates for the best of the three clocks referenced with the crystal oscillator. Clocks 2 and 3 differ little from the data shown. Differences in the shapes of the curves are evidently due to artifacts of the averaging and summing processes. Brown ad Brouwer purposely chose summing intervals which were not

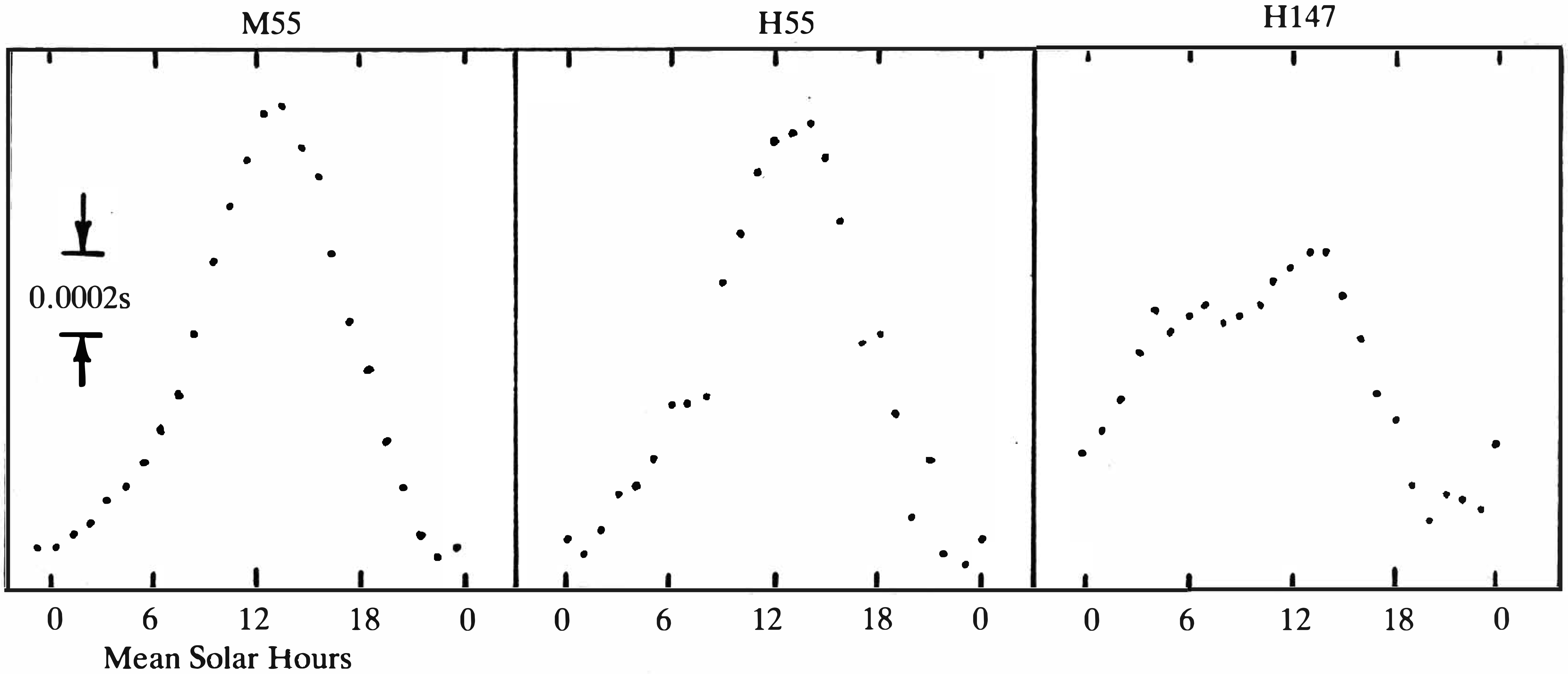

Fig. 1. Diurnal rate variation.

LUNAR DATA ANALYSIS

Let A = rate for hour 1, B = hour 2 . . . . . W = hour 23

Let 1 = day 1, 2 = day 2, etc.

	A1	B1	C1	D1	E1	. . . . .	U1	V1	W1	A2
	B2	C2	D2	E2	F2 . . .	. . .	V2	W2	A3	B3
	C3	D3	E3	F3	G3 . . .	. . .	W3	A4	B4	—
	C4	D4	E4	F4	G4 . . .	. . .	W4	A5	B5	C5
	D5	E5	F5	G5	H5 . .	. .	A6	B6	C6	D6
	.	.	.	.	.		.	.	.	.
	.	.	.	.	.		.	.	.	.
	.	.	.	.	.		.	.	.	.
	.	.	.	.	.		.	.	.	.
	.	.	.	.	.		.	.	.	.
SUM	AN	BN	CN	DN	EN . . .	. . .	UN	VN	WN	XN

where: A = Lunar hour 0, B = hour 1 etc.
Moon rise at hour 0 on day 1,
Moon rise at hour 1 on day 2,
„ „ at hour 2 on day 3,
„ „ at hour 2 on day 4,
„ „ at hour 3 on day 5

and again rate for hour 0 = AN/n, 1 = BN/n . . . .

Fig. 1A.

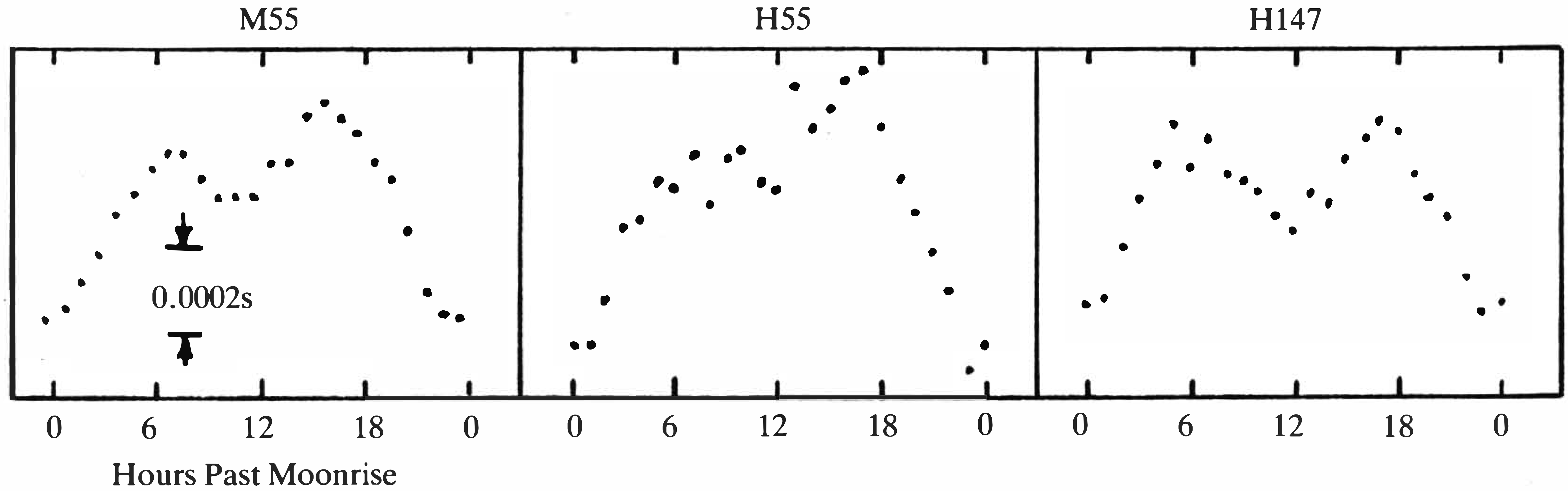

Fig. 2. Lunar cycle rate variation.

integrally related to the lunar cycle. They were quite concerned over what they considered to be an unusually high amplitude of the diurnal term and made the following statement, ". . . . the effect is probably due to temperature changes in the signalling system, including the forty mile telephone line from New York [City to Tuxedo Park]."

EARTH'S VARIABLE ROTATION RATE

The advent of crystal oscillators and atomic standards with good long term stabilities (1 part in 1E09 to 1E11) has made it possible to measure nutation and rate of rotation to reasonably high accuracies. There are three types of variations in rotation rate: secular (many 10's of years), sporadic and short term periodic (1 year or less). By international agreement, an imperical correction for seasonal variation was applied starting 1st January, 1956 to obtain the time called UT2. The formula adopted by the Bureau International de l'Heure is (Ref. 4):

$$\Delta SV = 0.22 \sin(2\pi t) - 0.017 \cos(2rt) - 0.007 \sin(4\pi t) + 0.006 \cos(4\pi t) \quad (6)$$

in seconds, where t is the fraction of a year. A plot of this equation is given in Fig. 3 below. It shows a variation of +35msec and −28msec over the course of a year. This is the order of variation one might expect to see when comparing any precision clock against celestial observations.

More and more articles dealing with the subject of the Earth's rotation rate and the length of day are appearing in scientific and quasi-scientific journals. One must be quite careful in interpreting the results presented in these articles. In many cases the authors show changes in the LOD of 1 to 3 milliseconds. Often they are talking about unclearly stipulated day to day or week to week changes and not the accumulated change in LOD which one would actually observe.

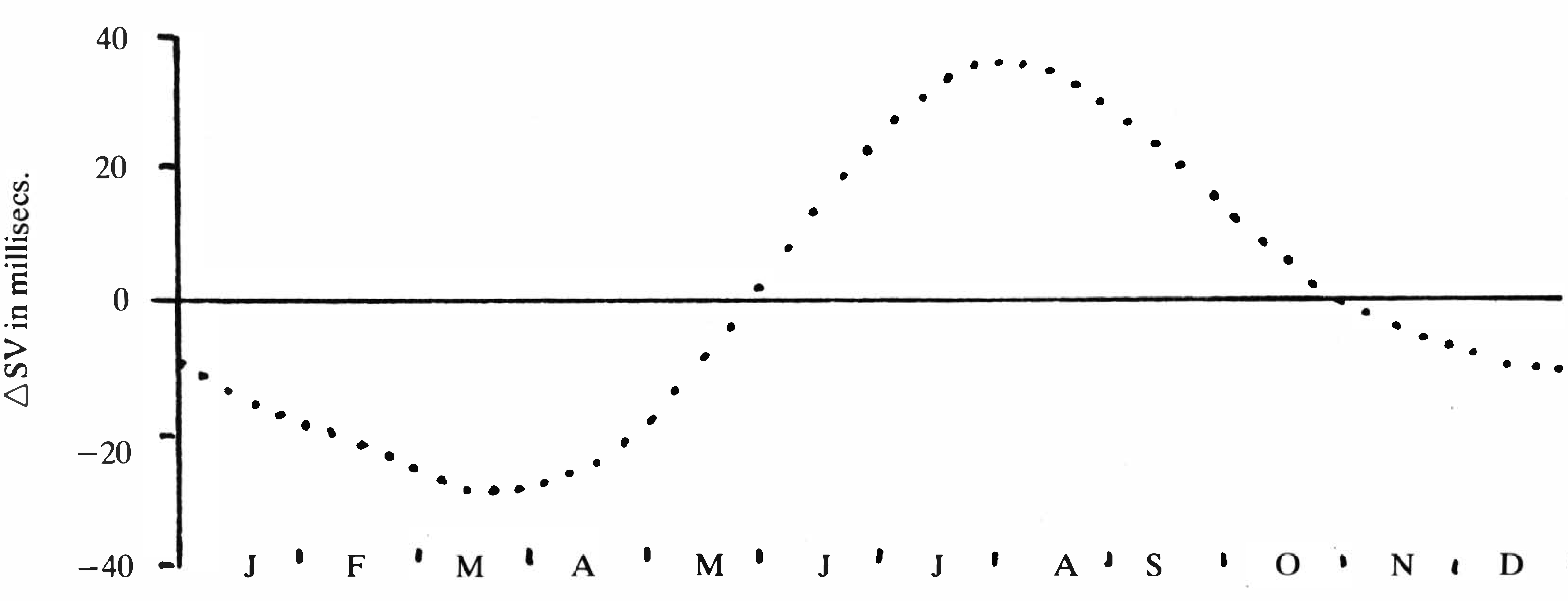

Fig. 3. Seasonal variations in length of day.

Species	*Symbol*	*Period*	*b*	*f(Ø)*	*ß(λ 1)*
Long period	Lunar	18.6 years	0·066	$\frac{3}{4}(\frac{1}{3} - \cos^2\Phi)$	$(N_{☾} - N_{☾_0})$
	Sa	1 year	0·012		$(\odot - 1°8)$
	Ssa	½ year	0·073		$2(\odot - 79°8)$
	MSm	$31^{d}85$	0·016		$(☾ - \odot + p_{☾})$
	Mm	$27^{d}55$	0·083		$(☾ - p_{☾})$
	MSf	$14^{d}77$	0·014		$2(☾ - \odot + 79°8)$
	Mf	$13^{d}66$	0·156		$2☾$
	. . .	$13^{d}63$	0·065		$2☾ + N_{☾} - N_{☾_0}$
Diurnal	O_1	$25^{h}82$	0·377	$\sin\Phi\cos\Phi$	$(qt + \odot - 2☾ - 169°8 + \lambda)$
	P_1	$24^{h}07$	0·176		$(qt + \odot - 10°2 + \lambda)$
	K_1	$23^{h}93$	0·531		$(qt + \odot + 10°2 + \lambda)$
	N_2	$12^{h}66$	0·174	$\frac{1}{2}\sin^2\Phi$	$2(qt + \odot - \frac{3}{2}☾ + \frac{1}{2}p_{☾} - 79°8 + \lambda)$
Semi-diurnal	M_2	$12^{h}42$	0·908		$2(qt + \odot - ☾ - 79°8 + \lambda)$
	S_2	$12^{h}00$	0·423		$2qt$
	K_2	$11^{h}97$	0·115		$2(qt + \odot - 79°8 + \lambda)$

$\odot$ is the longitude of the "mean Sun", increasing by 0°0411 per mean solar hour.
☾ is the mean longitude of the Moon, increasing by 0°5490 per mean solar hour.
$p_{☾}$ is the mean longitude of lunar perigee, increasing by 0°0046 per mean solar hour.
$N_{☾}$ is the mean longitude of the lunar ascending nodes, increasing by − 0°0022 per mean solar hour.
q is the angular velocity of the Earth relative to the mean Sun, 15° per mean solar hour.
$\Omega = q + \frac{d\odot}{dt}$ is the angular velocity of the Earth relative to the stars, 15°0411 per mean solar hour.

Fig. 4. Parameters for some Equilibrium Tides.

At this point it would be instructive to calculate what effect the change in rate of rotation might have on effective gravity due to the acceleration of centrifugal force. Using the familiar equation:

$$a = \omega^2 r \quad (7)$$

where w = 2π/86400 rad/sec and r = 4.089EO8 cm at 40° latitude and introducing a change in period of △t = 0.06 in 86400 seconds, the component of centrifugal force acting in opposition to g is something like 2.4E-06 cm/sec² = 2.4 microgals. This is perhaps larger than one might expect but trivial when compared with something like 200 microgals due to Sun and Moon gravitational attractions.

EARTH TIDES

Tides per se are, of course, an effect and only in a secondary way a cause of variations in local gravity. However it is common practice to refer to the various primary, secondary and interactive components as gravity "tides". Munk and MacDonald (Ref. 5) present a very convenient formula and table for computing tides which they lifted from the Admirality Manual [Doodson and Warburg, 1941]. The tide potential may be written:

$$U = gKbf(Ø)\cos(ß(\lambda,t)) \quad (8)$$

where: $K = 3ma^3/2Mr^3 = 8.43E\text{-}08$.

K is the general lunar coefficient with: m = Moon's mass, M = Earth's mass, r = Moon's distance and a = Earth's radius. Substituting values for b from the table will give values for the half amplitude of U in microgals for the "tide" in question. Using the argument ß with appropriate values will provide the proper time and phase dependent values for the function. Here λ refers to longitude.

Since it is quite impossible to visualize what these multiple periodic functions will look like when summed on an hour by hour — day by day basis, Fig. 5 is an example of what a two week record from a typical gravimeter might look like. This pattern will repeat, with slight variations. Note that the major dip in the gravimeter wave is precessing through the day as expected with a period greater than 24 hours. The maximum peak to peak variation is of the order of 240 microgals. The small notch in the top of the wave is about 40 microgals.

Now that we have something tangible in the form of calculated and observed variations (△g) in local gravity (g), it is possible to

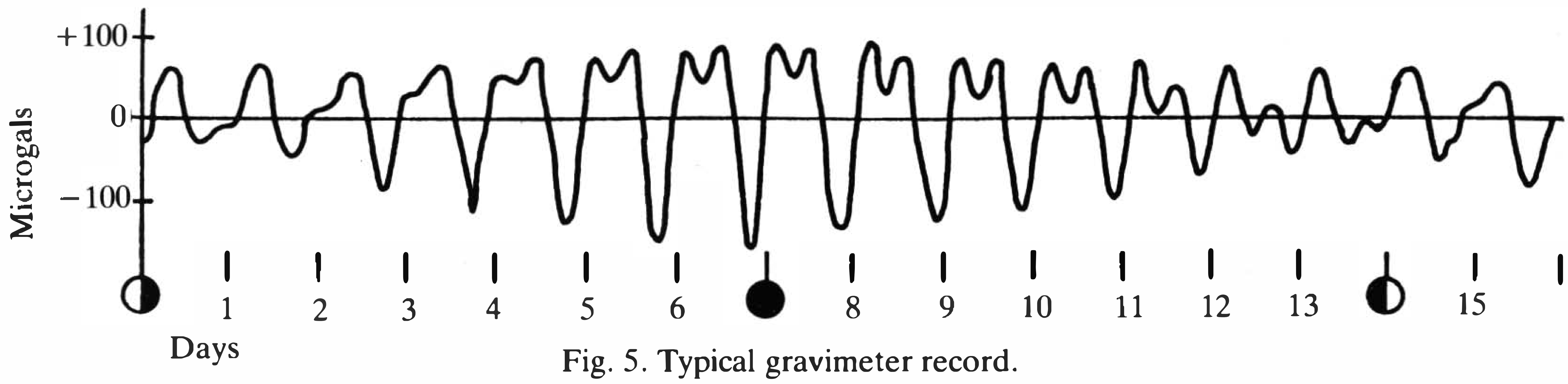

Fig. 5. Typical gravimeter record.

relate Δg to changes in the period of a pendulum ΔP in the following manner:

$$P_1 = 2\pi u \sqrt{L/g}$$

$$P_2 = 2\pi \sqrt{L/g + \Delta g} = 2\pi \sqrt{L/g} \cdot \sqrt{g/g + \Delta g}$$

$$\text{let } Q = \sqrt{g/g+\Delta g} = \sqrt{g/1 + \Delta g/g} = \sqrt{1 - \Delta g/g} = (1 - \Delta g/2g)$$

$$\text{then } P_2 = 2\pi \sqrt{L/g} \cdot (1 - \Delta g/2g) \text{ and } \Delta P = 2\pi \sqrt{L/g} . (-\Delta g/2g)$$

$$\Delta P = -P_1 \, \Delta g/2g \quad (9)$$

Equation 9 is a very convenient formula for calculating the effects of small changes in gravity on the period of a pendulum. In like manner the formula for calculating the effects of small changes in length is:

$$\Delta P = +P_1 \, \Delta L/2L \quad (10)$$

Melchior (Ref. 6), citing the work of Jeffrey's and Bartels, has developed a very convenient formula which permits us to easily calculate the effects of any, or all, of the major tides on the period of a pendulum. It is worthwhile to reproduce the derivation here because the only edition of Melchior which has it is out of print, hard to find and the results are of interest to horologists working with very high precision pendulums. Starting with formula (9):

$$\Delta P/P = -\tfrac{1}{2}\, dg/g = \frac{w_2}{2ga}$$

We can omit terms greater than the second order which then gives:

$$\Delta P/P = \tfrac{1}{ga} W_2$$

To obtain the correction for the clock at any given time it is necessary to integrate:

$$\Delta T = \tfrac{1}{ga} \int W dt$$

The function W consists of a sum of trigonometric functions with the typical periodic argument $(\omega t + \lambda)$ where ω is the frequency of the particular function in degrees per hour. Applying the function W in the following calculations we will take the second as the unit of time. ω_i can then be expressed as a function of the angle (15° = 1h).

$$\Delta T = (1/ga)\,(86400/2\pi) \int W dt \quad (11)$$

The principal terms of the function W with their coefficients as given by Bartels (Ref. 7) are:

$$W = 0.5G\,(1\text{-}3\sin^2\Phi)\,[0.15642 \cos(\omega_{Mf} t + \lambda_{Mf}) + 0.08254 \cos(\omega_{Mm} t + \lambda_{Mm})]$$

$$+ G \sin 2\Phi\,[0.37689 \cos(w_{oi} t + \lambda_{oi}) - 0.53050 \cos(\omega_{K1} t + \lambda_{K1})]$$

$$+ G \cos^2\Phi\,[0.90812 \cos(\omega_{M2} t + \lambda_{M2}) + 0.42286 \cos(\omega_{S2} t + \lambda_{S2})]$$

Substituting in equation 11 we obtain:

$$\Delta T = G/ga \; 86400/2\pi \; f(\Phi) \int [W]dt = 5.76E\text{-}04\,(\Phi) \int [W]dt$$

where: G is Doodson's constant =26.206 cm²/sec², Φ = latitude and $f(\Phi)$ depends on the type of tide (a, b or c), g =982.04 cm/sec² and a = 6371.221 km (Earth's radius). The general form of the answer for any term (i) then becomes:

$$\Delta T = 5.76E\text{-}04\,(\Phi)\; b_i/w_i \sin(\omega_i t + \lambda_i) = B_i f(\Phi_i) \sin(\omega_i t + \lambda_i) \quad (12)$$

where bi is the same as the b shown in the table of Fig. 4. The values of Bi and $f(\Phi)$ for two different latitudes are given in the table of Fig. 6 below. A casual look at the factor b (bi) would lead one to expect the M_2 wave to be the dominant effect and the presence of ocean tides supports this conclusion. However a closer examination of the product of factors Bi and $f(\Phi)$ clearly indicates that K_1 is the dominant wave, closely followed by O_1. Also note the beat between the K_1 and O_1 waves which results in the fortnightly wave M_f.

When applying the constants shown in Fig. 6: $\omega_i = 15 w_i$ in degrees per hour, λ_i is the relative phase angle in degrees, t is in hours and ΔT will be the change in period expressed

Wave	w_i	b_i	B_i	f(Ø)@40°	f(Ø)@50°
M_f	0.0732022	0.15642	0.001230	0.000295	0.000935
M_m	0.0362916	0.08254	0.001310	0.000314	0.000996
K_1	1.0027379	0.53050	0.000305	0.000300	0.000300
O_1	0.9295357	0.37689	0.000233	0.000229	0.000229
M_2	1.9322736	0.90812	0.000271	0.000159	0.000112
S_2	2.0000000	0.42286	0.000122	0.000072	0.000050

Fig. 6. Table of Constants for calculating ΔT.

as parts of a second. B_i = 5.76E-04 $(b_i)/w_i$ and f(ϕ is the result of integrating the appropriate term of W and includes a scale factor of 1E-04. As an example ΔT resulting from the M_2 wave is 0.000271 × 0.000159 = 4.31E-08 seconds per second or ±155 μsecs/hr as the maximum amplitude of a change in period as measure in 1 hour increments. This is about twice the value observed in Fig. 2 or what might be expected from gravimeter results (Fig. 5) but it is only one component of a complex waveform.

RECENT WORK

In the latter half of 1984 the author was privileged to put the master pendulum of Shortt Number 41, located at the U.S. Naval Observatory in Washington, D.C., back in operation. This was accomplished by substituting modern solid state electronics for the somewhat finicky slave pendulum. Fortuitously, in some bygone day someone had mounted a first surface mirror near the top of the rod and installed an optically flat window in the side of the bell jar (see Fig. 6A). These additions made it relatively easy to project a light slit onto the moving mirror, back out through the window and then detect the position of the pendulum with two photo detectors. The first detector is located at the position of maximum velocity (ϕ = 0) and is used to generate timing pulses. The second detector is mounted at 0.75° right deflection, the point of release for the gravity impulse arm. With the detectors in operation it is a relatively straight-forward matter to count out 30 seconds between drive impulses to the pendulum.

The Naval Observatory maintains several atomic standards of both the cesium beam and hydrogen maser types. Once each hour a computer electronically reads each standard and the readings are averaged to form what is often called a "paper clock". At one quarter past each hour the computer also reads the timing pulse from the Shortt clock, compares it with the paper clock and records the difference. Since there is always some jitter associated with a reading, the computer actually takes eight readings at two second intervals and averages the result. The current hourly average is subtracted from the previous hour's average to give the first difference, or hourly rate. Before proceeding

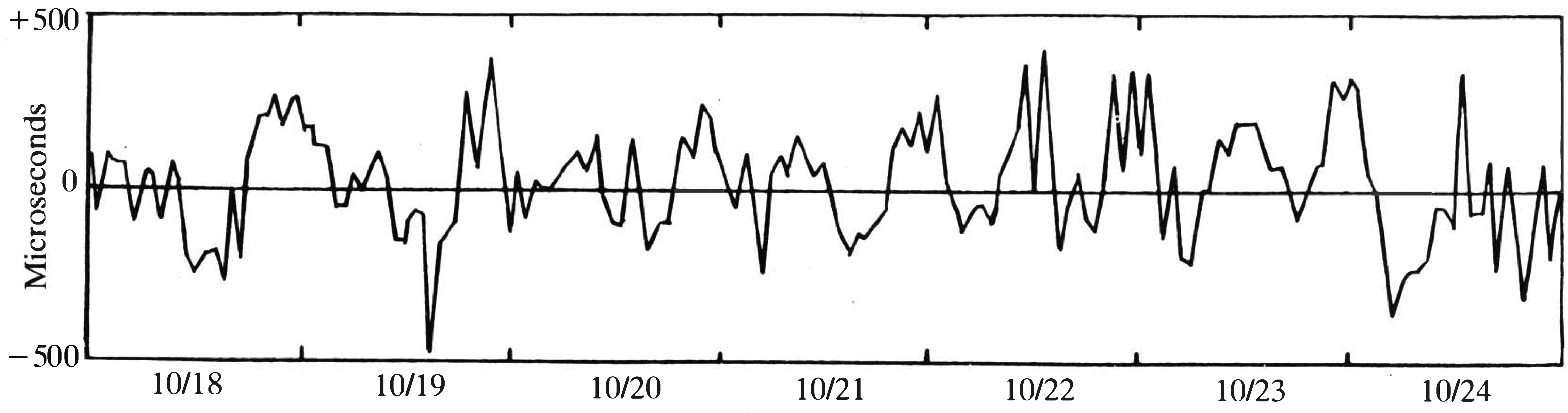

Fig. 7. Hourly rate variation of Shortt No. 41.

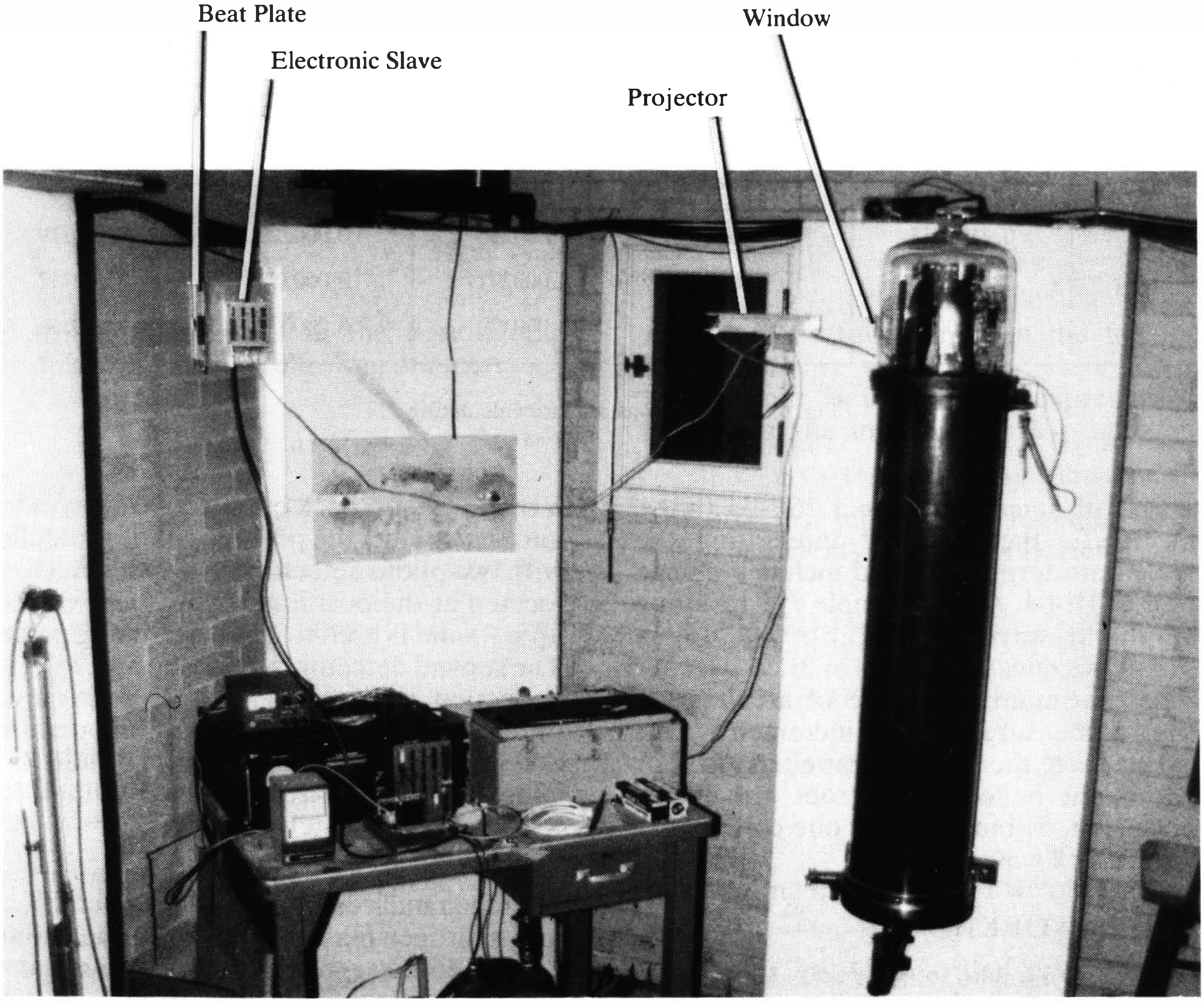

Fig. 6A. Shortt Number 41 with electronic slave.

further we should note that the results presented here reflect the judgement of the author and not necessarily those of the Naval Observatory. Furthermore, use of the facilities should not be construed to imply any endorsement of the project or its results by the U.S. Navy or the Naval Observatory. Every few weeks the computer is asked to print out its record and subsequent processing was carried out by the author.

During the first month of operation the pendulum showed an average gaining rate of roughly 0.0065 secs/hr. This steady gain was subtracted from the first difference and the result is plotted in Fig. 7 for a typical week during the period. There is nothing singular about this week, any other week would look very much the same.

Following the same procedure as Brown and Brouwer, which is outlined earlier in this paper, the data was then processed to show solar and lunar gravitational effects on rate, Figs. 8 and 9. While these plots are most interesting, similar to Brown and Brouwer's results and about what one might expect, a moment's reflection raises some questions. Consider the curves shown in Fig. 10. The solid line represents the change in period one could expect from the diurnal change in local gravity for a day of maximum excursion as shown in Fig. 5 and computed using equation 9. The dotted curve is simply the data shown in Fig. 9 smoothed and properly oriented to be compatible with the gravimeter derived curve. The striking anomaly is the dominance of the semi-diurnal term. This may be explained as an artifact of the summing (or integrating) process which may also be viewed as a band pass filter. Summing at the lunar period (twice 12h 25m) over 30 days will tend to suppress the diurnal waves K_1 and O_1 leaving the strong lunar wave M_2. If this is true, why didn't it appear in Brown and Brouwer's results?

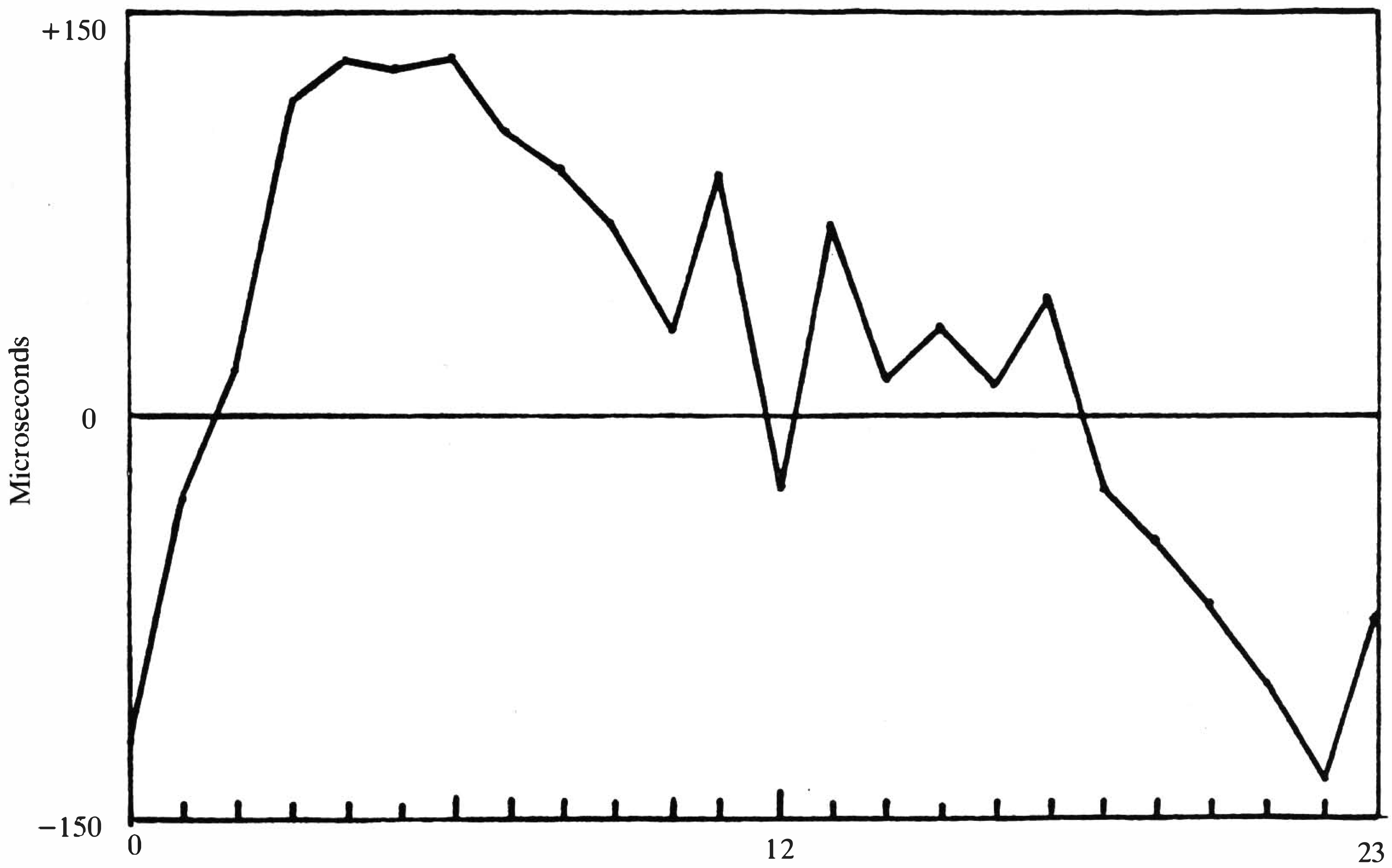

Fig. 8. Average diurnal rate changes.

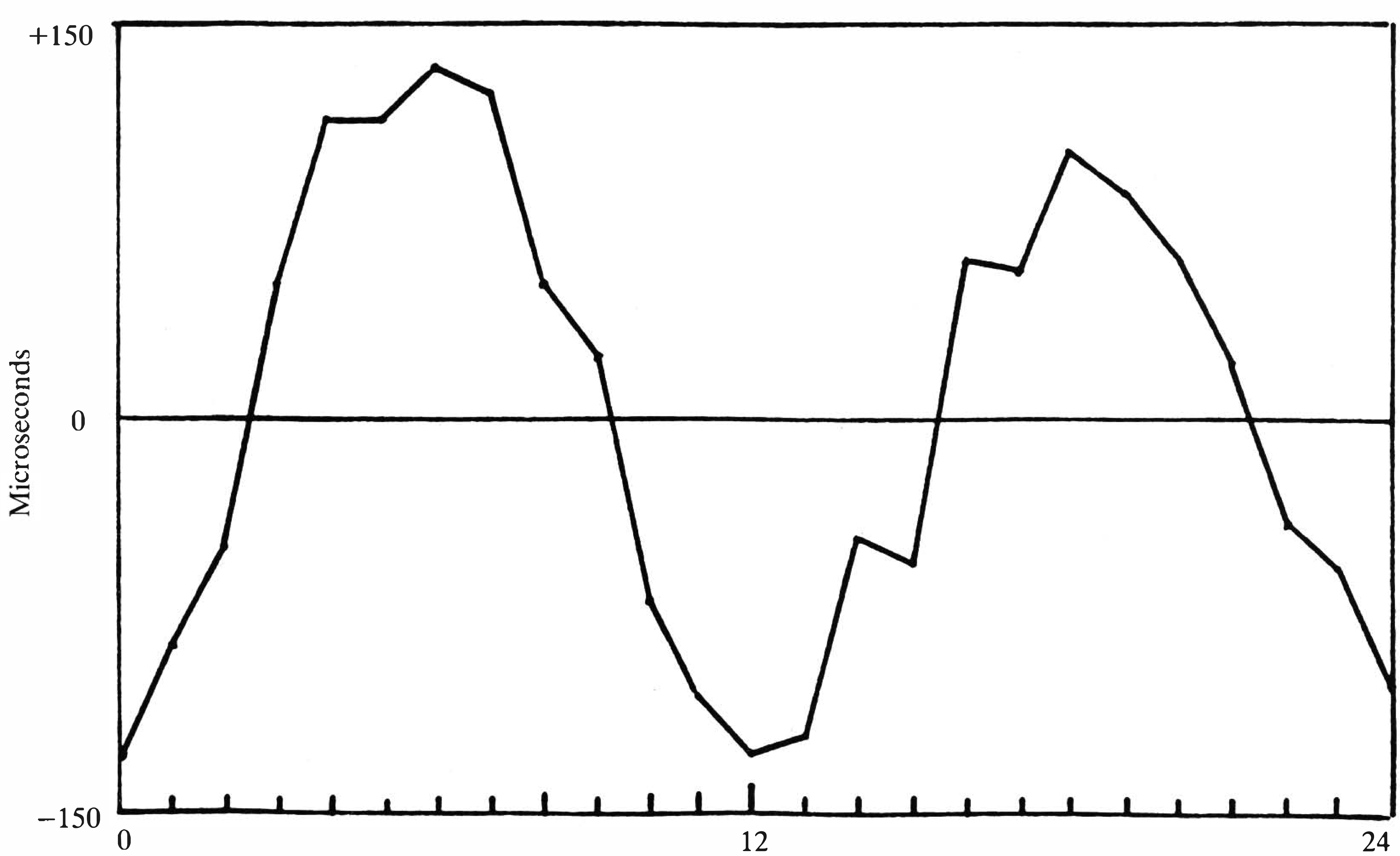

Fig. 9. Average lunar cycle rate changes.

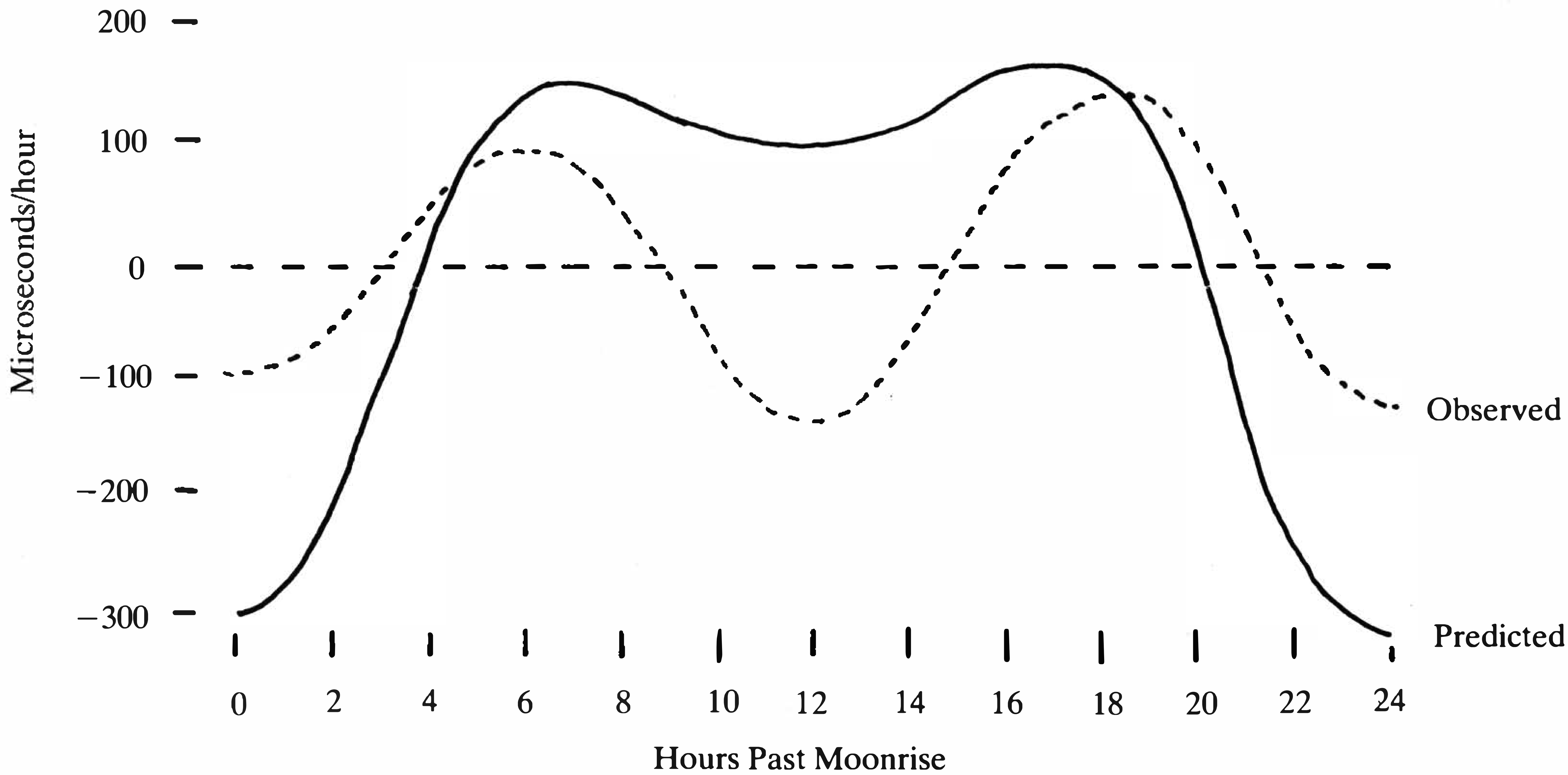

Fig. 10. Predicted and observed rate changes.
Lunar M_2 component only.

THE PENDULUM AS A GRAVIMETER

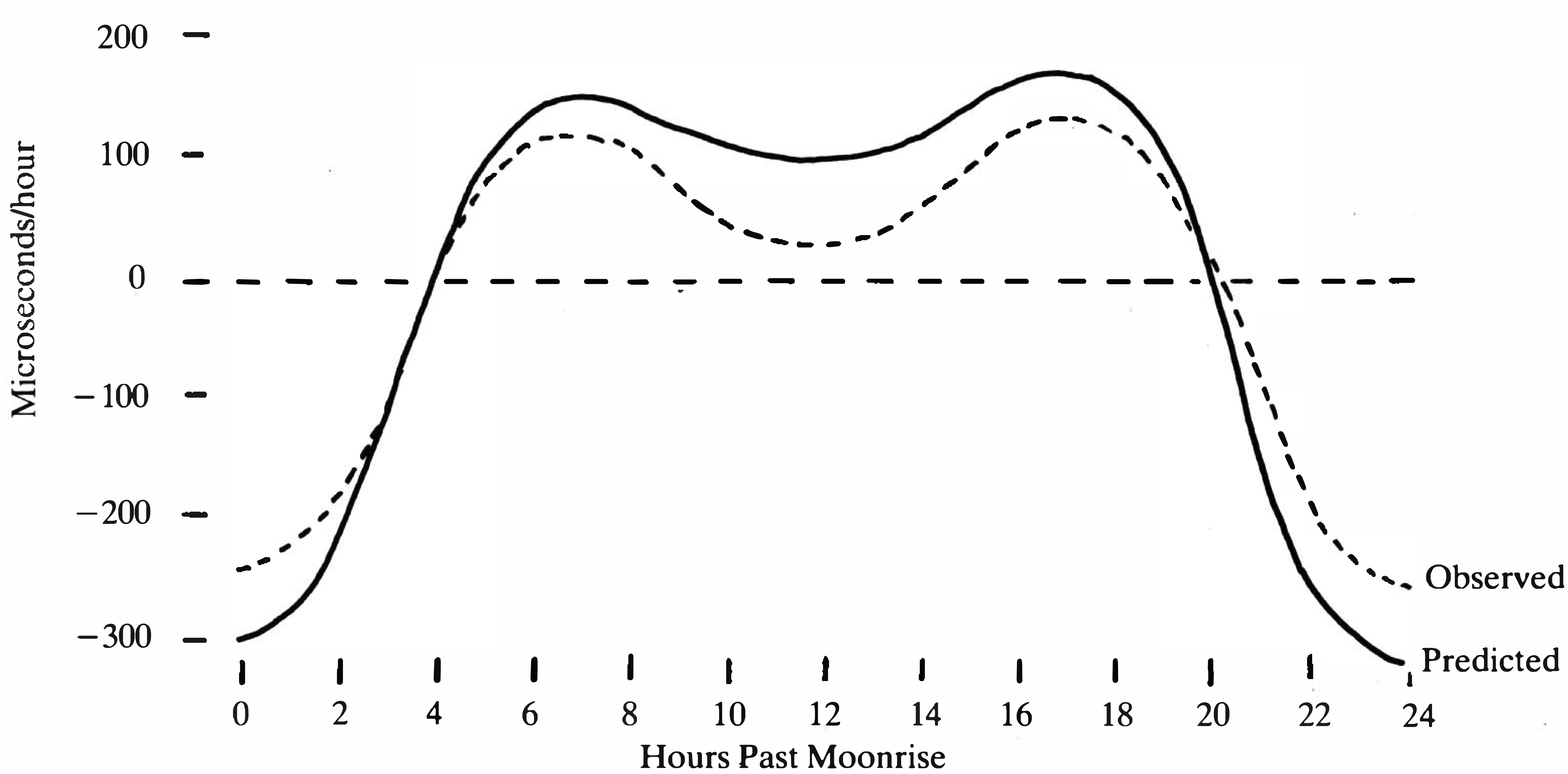

Fig. 11a. Predicted and observed rate changes.
Full moon phase only.

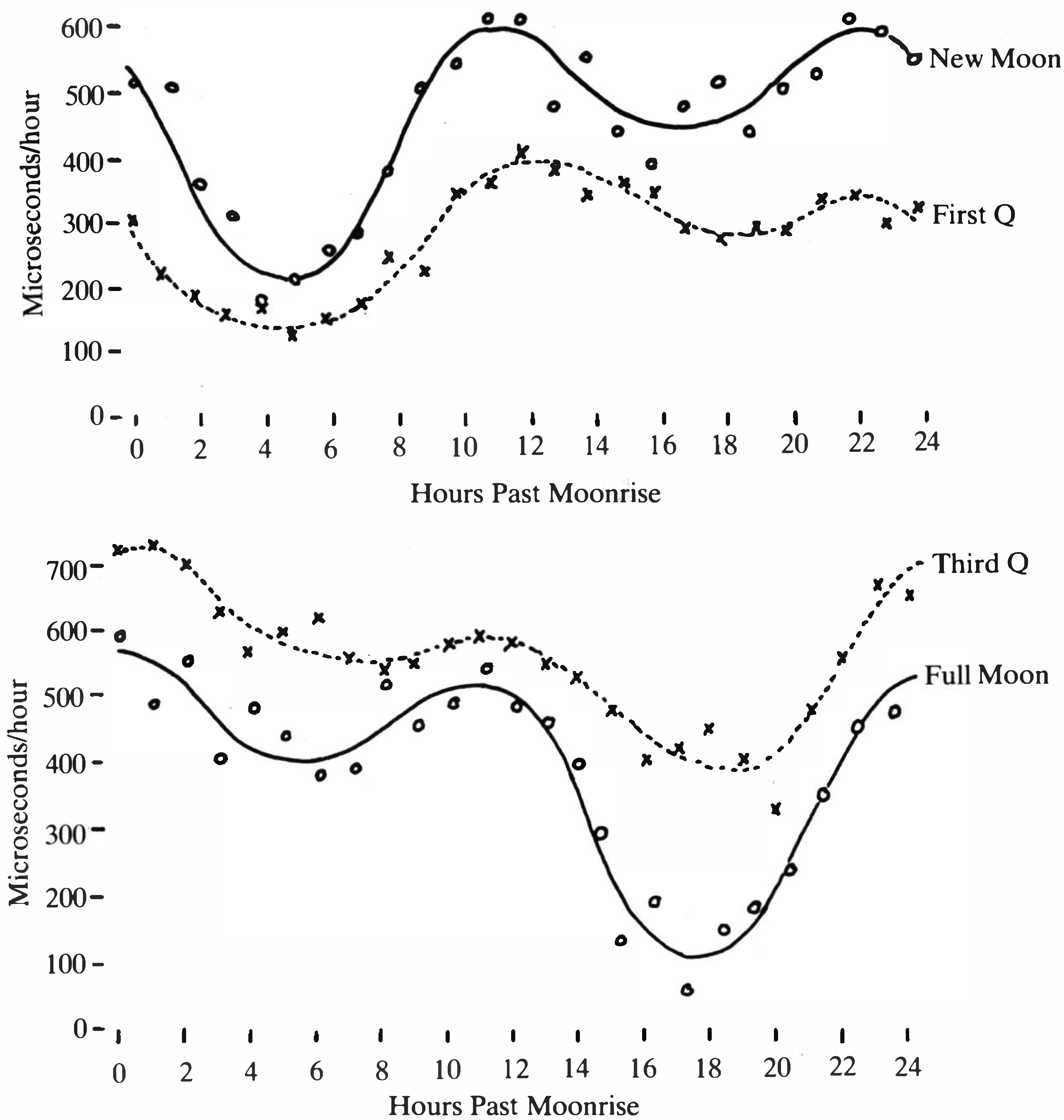

Fig. 11. Rate changes as a function of moon phase.

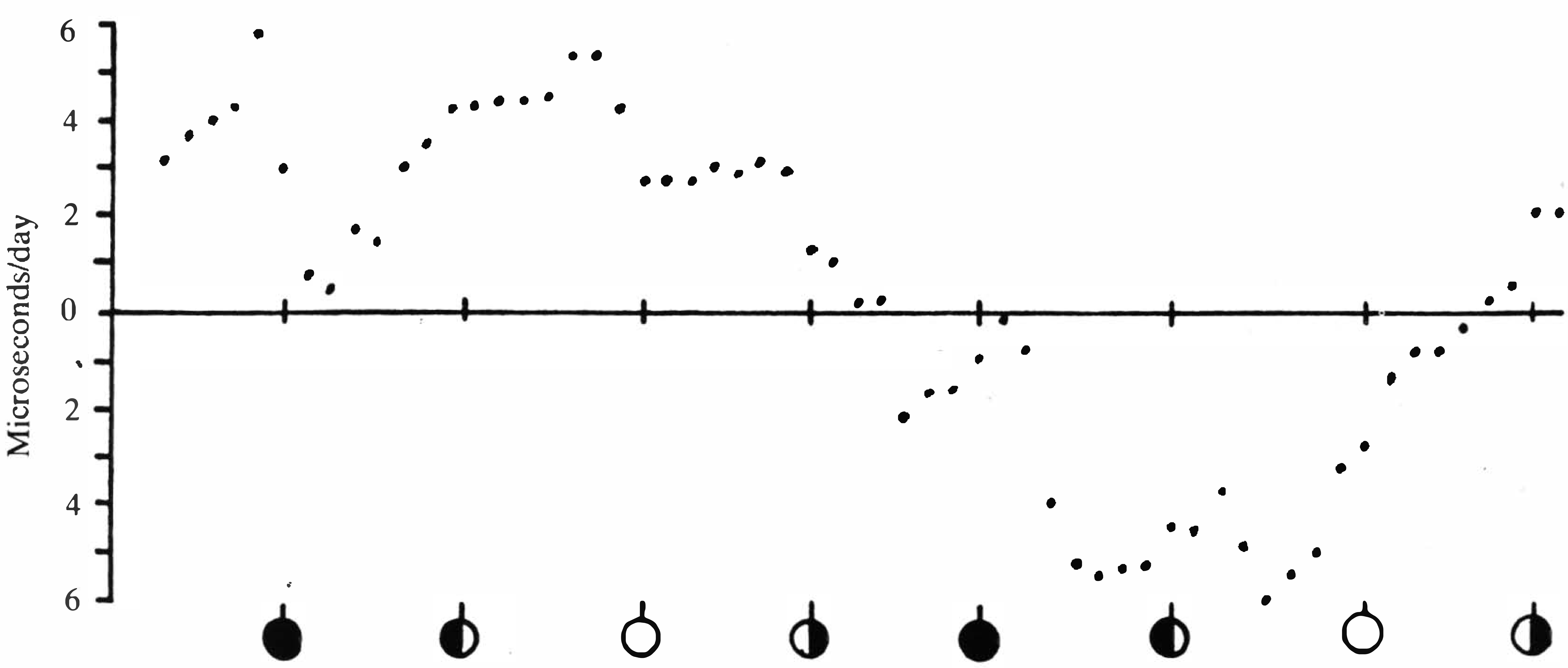

Fig. 12. Shortt No. 41 Daily rates 10/19 - 12/16/84.

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Scottish Section

The Inaugural Meeting of the Society took place in the Library of the Society of Antiquaries, Royal Museum of Scotland, Queen Street, Edinburgh on 12th October, 1985.

The meeting acknowledged their appreciation of Mr. Felix Hudson who was largely responsible for the setting up of the section.

The first part of the meeting was Dr. Allan Simpson of the Royal Museum of Scotland explaining the current reorganisation of the Edinburgh Museums (Royal Scottish and National Museum of Antiquities).

This was followed by a talk by the AHS Chairman, Mr. Tom Robinson, on the thirty hour Longcase Clock. This has been written up elsewhere, and Mr. Robinson illustrated the talk with a Large number of Slides which showed that the same makers made different types of thirty hour movements (posted and plated frames). It is also true to say that the quality also varied in movements apparently from the same makers. The point was also made that the most eminent of makers produced thirty hour clocks, and that they were not just the product of the village makers. This was a most informative talk, and perhaps the only question unanswered was why the thirty hour clock is so rarely found in Scotland.

On the 7th December the section had its second meeting at the Royal Museum of Scotland, Chambers Street, Edinburgh. The Speaker was Mr. Beresford Hutchinson of the Old Royal Observatory, Greenwich who gave a talk on "The development of the English pendulum Clock" which took us through the first twenty or so years of the Domestic Clock. The varieties tried out during this period of the early clocks were many. These were well illustrated, and the settling down of style into what were to become the standard eighteenth century longcase and bracket clock proved to be a fascinating study.

There was a good turn out for the meeting with some members travelling from Aberdeen for the occasion.

Future meetings planned are at Glasgow Art Gallery and Museum on 22nd February at 2.00 where Mr. John Redfern will talk on "Some Aspects of Clock Restoration". Members will also have the opportunity to preview a Horological Educational Exhibition "As Time Goes By" which will be on display from the latter part of February.

On 22nd March there will be a joint meeting with the Scientific Instrument Society which is a Symposium of lectures — "The Business of Instruments".

In early April we intend to hold a Joint meeting with the Furniture History Society when Sarah Medlam of the Bowes Museum will lecture on "French Clock Cases".

The Scottish Section is unique in the AHS as the small membership is spread over a very large area. It is to be hoped that joint meetings with other Societies will ensure a worthwhile attendance at all meetings.

Kenneth Chapelle.

Information about the Section may be obtained from its Secretary, c/o Ticehurst office.